**1425 Emmonak RPSU Power Plant and Bulk Fuel Upgrades**
**Combined Project, Including Alakanuk Standby Power Module**
**Final Closeout Summary Report April, 2018**

This Closeout Summary Report is filed with the federal grantor agency the Denali Commission ("Denali" or "DC") by the grantee partner Alaska Village Electric Cooperative, Inc. (AVEC). The federal grant award covered by this report and this project is 01425-00 (or "1425"), as subsequently amended. AVEC was the grantee of DC funding for this project; the participants are AVEC and the City of Emmonak (City). As owner and operator of their respective new facilities, each participant is responsible for future maintenance thereof.

This project is being closed because the project is complete and is in full operation, and the funding has expired. This report represents the project status as of December 31, 2017. As of that date, total project outlays exceeded total project funding by $29,008, and no federal funds are available for deobligation.

**Background** – AVEC is a rural electric cooperative serving 57 rural Alaskan communities, all of which (with one exception) are generally accessible only seasonally by ship, and year-round only by aircraft. Consumers in these rural Alaska communities pay some of the highest electric power rates in the U.S. Emmonak, Alaska (population 856) is an AVEC member community located well off the state's road system and electrical grid on the north bank of Kwiguk Pass, a river channel in the terminal delta of the Yukon River, 10 miles from the Bering Sea, surrounded by the Yukon Delta National Wildlife Refuge. It lies 120 air miles northwest of Bethel and 120 air miles southeast of Nome, the closest regional "hubs" with extensive transportation and government services. A transitional maritime climate predominates in Emmonak. Temperatures range from -25 to 79 °F. Annual precipitation averages 19 inches, while snowfall averages 50 to 60 inches per year. The navigable waters surrounding Emmonak are generally ice-free only from June to October. As of July, 2017, the retail prices of gasoline and diesel/heating fuel were $5.89 and $5.34, respectively. The community incorporated in 1964 under state law as a second class city.

Alakanuk, Alaska (population 707), another AVEC member community, lies 8 miles southwest of Emmonak and is its closest neighboring community. The Alakanuk community incorporated in 1969 under Alaska state law as a second class city. Emmonak and Alakanuk are now connected by an electrical intertie and thus together comprise one electrical grid.

**Activities** - The scope for this project involved the design and construction of a 3.14 MW diesel-fired electric power plant and related 563,000 gallon (gross capacity) bulk fuel storage tank farm, and related storage areas and housing facilities (for AVEC's traveling employees), including site preparation, foundations, generation and controls equipment and associated interconnecting fuel piping and electrical wiring, transformers and other necessary electrical distribution upgrades, marine header used seasonally when filling the bulk fuel tanks from oceangoing barges, spill response equipment and other equipment. The new power plant features heat exchangers and other components designed to capture excess heat off the diesel engines and transfer that heat to the space heating systems of nearby candidate receptor buildings (also known as "off-takers"). The scope also included installation of a 12,000 gallon double-wall bulk fuel storage tank for the City's water treatment plant (WTP), and refurbishment of the WTP's four existing tanks comprising about 30,000 gallons storage. Finally, the scope included installation of a standby power plant in Alakanuk, at the other end of the existing transmission intertie, and connection of both the Emmonak

prime power plant and the Alakanuk standby power plant to the existing intertie. All bulk fuel tanks newly installed or refurbished during this project are diesel/heating fuel storage tanks.

The new prime power plant and its bulk fuel tank farm are each located almost directly across from each other on opposite sides Delta Street in Emmonak in a commercial/industrial area; the power plant lies about 700 feet north of the Kwiguk Pass river bank and the tank farm about 400 feet north of the bank. The parcel of land for the new tank farm was provided by the City; the parcel of land for the new power plant was already owned by AVEC and contained AVEC's pre-existing, aging power plant and tank farm. As of the date of this report, all design and construction included in the scope of award 1425 is now complete, and the facilities are satisfactorily operating.

This project and facilities completed under award DC 1425 were developed and built as part of an amalgamated, long term strategic program of energy projects for Emmonak and Alakanuk that also included installation of 400kW of wind generation capacity in Emmonak, and a 12.47 kV electrical intertie constructed to connect the two communities' power grids; both the wind farm and the intertie were constructed in 2010-11 and were funded by a single grant from the State of Alaska's Renewable Energy Fund, managed by the Alaska Energy Authority (AEA), together with AVEC matching contributions. This intertie was included in the comprehensive feasibility study of potential AVEC interties funded by DC award 356-07 (DC project 73A); that study concluded that the Emmonak – Alakanuk intertie was feasible (i.e., bore a positive benefit-cost ratio). AVEC's then-existing prime power plants in Emmonak and Alakanuk were roughly equivalent in age, efficiency, capacity, and other metrics; AVEC chose Emmonak as the site for a new prime power plant to serve both communities on the basis of the more favorable logistics for that community. A new power plant in Emmonak would include modern, remotely-accessible control systems and upgraded generators to maximize fuel efficiency and to integrate and utilize the wind turbines' variable power output to the greatest extent possible.

AVEC has long maintained prioritized rankings of its RPSU and BFU facilities, with the goal of first upgrading those with the highest environmental risk exposure; and/or those presenting the greatest opportunity for increases in fuel efficiency (defined as kilowatt-hours produced per gallon of fuel), such as through consolidation and interconnection of communities, or through replacement of older, less efficient generators and control systems, or through incorporation of renewable energy sources, etc. Replacement and retirement of the old Emmonak power plant with a new, modern, efficient plant, together with replacement and retirement of the old Alakanuk power plant with a standby backup module only, accomplishes several of these goals, most notably: increased operating efficiency; lower operating and maintenance costs (due primarily to one fewer prime power plant in the AVEC fleet); interconnection and consolidation of generation and fuel storage with the construction of the intertie to Alakanuk; installation of control equipment into the power plant that facilitates integration of renewable energy sources such as the 400kW AVEC wind farm now operating in Emmonak (see above); and increased, concentrated opportunity for heat recovery from the single remaining prime power plant.

Consulting engineers URS Corporation (consulting engineers) first published plans for upgraded bulk fuel facilities for three Emmonak entities (AVEC, the City, and the Lower Yukon School District (LYSD)) in

its Conceptual Design Report (CDR) dated May 2002. After AVEC added the wind farm and the intertie to the local energy infrastructure in 2010-11, DC award 1288 provided initial preliminary design funding for both the new power plant and its bulk fuel storage facilities; AVEC was the grantee and sole participant for award 1288; primary deliverables and accomplishments under 1288 included the updated CDR for the new AVEC tank farm, and site control, and a geotechnical investigation of the chosen sites (including on-site extraction of core samples). Final design funding for both new facilities was included in the subject construction award 1425. The updated CDR was published in September 2013 by consulting engineers Hattenburg Dilley and Linnell (HDL) and covered facilities for just AVEC and the City. Both CDR's focused primarily on bulk fuel storage, but also included consideration and discussion of other components of the community's energy infrastructure. AVEC's required tank farm capacity was determined by projecting population trends, power demand, and fuel usage data to a design year of 2022 for both communities.

HDL's updated CDR considered five potential sites for a new AVEC tank farm; each site was sized to also accommodate future construction of a new prime power plant large enough to power both Emmonak and Alakanuk by way of the recently-completed intertie; AVEC and HDL determined the parcel designated as Site 2 was the most feasible site, and AVEC elected to construct its new tank farm there. Advantages of Site 2 relative to the other sites studied included its central location in the community near to the existing power plant and the river bank, thus offering the possibility to minimize some major construction costs including: less work to relocate equipment and structures, less length of piping needed to connect the tank farm to the anticipated new power plant and also to the barge fill point at the marine header, and less required upgrades to connect to the grid. Also geotechnical characteristics of building at Site 2 would require minimal fill material for construction of the gravel pad for the bulk fuel facility. Further, the Site 2 location was proximate to several promising heat loads which would ultimately be prime off-taker candidates for the recovered heat system that will transfer excess heat produced by the power plant's generators to the heating systems of these facilities, and thus displace much of the expensive imported heating fuel now consumed to heat them. At time of site selection, the heat recovery system was in the design stage; as of this report it is completed and operating, funded through construction by a grant from the State of Alaska Renewable Energy Fund to the City of Emmonak; nearby recovered heat off-takers will include the City's WTP (primary candidate) and the Boys and Girls Club. However it was also recognized at site 2 an erosion evaluation would be necessary during design to develop and evaluate designs that would mitigate risk to the facility from continued erosion of the nearby north bank of Kwiguk Pass.

This plan also envisioned decommissioning Alakanuk's power plant and its bulk fuel tank farm and replacing it with a standby-only generator module designed to power Alakanuk during short periods whenever power is not available over the intertie from the Emmonak prime plant, and which could power essential loads in both communities during short periods whenever the Emmonak prime power plant is offline but the intertie is operational. AVEC decided to install the Alakanuk standby power plant before the Emmonak power plant because a new school was then being constructed in Alakanuk; the standby power plant represents the additional generating capacity necessary to serve this additional load in Alakanuk until the new Emmonak prime power plant was completed and can power both communities through the intertie.

AVEC developed a strategic plan to complete two major community infrastructure projects in Emmonak (power plant and tank farm) concurrently in order to support a competitive bid process which would encourage bidding construction contractors to plan for optimal utilization of construction resources, especially heavy construction equipment (certain pieces are relatively expensive and would have to be barged in) and skilled labor, to result in lower construction costs overall.

The new Emmonak AVEC prime power plant is located only about 200 feet from the community's WTP, which consumes significant amounts of diesel fuel in its operations. The colder the ambient temperature, the greater the rate of fuel consumption at the WTP; so consumption is greater in winter than in summer. Community electric demand is also greater during the shorter (darker), colder days of winter than in summer, so the new AVEC power plant likewise consumes more fuel and produces more recoverable heat in winter, and less in summer. Thus the heat supply curve (at the power plant) and heat demand curve (at the WTP) relatively conform with each other when looked at seasonally; further, the short distance between the two facilities leads to minimal transfer loss in the system; as a result the heat recovery system (comprised of heat exchangers at the power plant and in the off-taker facilities combined with pumps, piping, and a liquid heat transfer medium) is expected to annually displace approximately 20,000 gallons of diesel fuel that would otherwise be additionally consumed at the WTP and other off-takers.

The new power plant consists of two connected buildings; the larger main one-story generation building contains all generators and controls, etc., and a smaller two-story building features storage on the main floor (to maintain a ready local stock of replacement parts, lubrication and other maintenance supplies), and transient employee housing on the upper floor. The generation building was erected onsite from a factory-prepared steel frame; then walls consisting of prefabricated, bonded, 3-layer panels (sheet metal/foam insulation/sheet metal "sandwich") were attached to the frame. The housing/storage building was shipped in two large adjacent halves which were then attached together on site. The entire plant is elevated above expected flood stage onto a common structural steel deck supported by a foundation consisting of steel pilings driven through a gravel pad; a poured concrete floor covers the entire interior portion of the steel deck, and a grated steel walkway surrounds the exterior at floor level.

The generation building itself has four firewall-isolated sections, two of which are generator bays placed one on each end of the building. Bay 1 contains two new Caterpillar model 3456 gensets, each rated at 450kW; bay 2 contains one Caterpillar model 3512 genset taken from the pre-existing decommissioned Emmonak power plant and rated at 940kW, plus one new Caterpillar model 3516B genset rated at 1.3 MW. All gensets are mounted on skids, and the skids are in turn mounted to the concrete floor of the plant with vibration-isolating skid supports.

The other two rooms sit in a middle section of the generation building between the two generator bays: a parts storage/work room which also contains a day tank and fueling system; and a controls room. The control systems include modern switchgear and other equipment designed to optimally balance the four diesel generators and the four wind turbines against the demand load of the two communities with the goal of maximizing efficiency, and to synchronize with the standby power plant in Alakanuk when that is called for, and to allow remote monitoring and control of critical metrics and functions from AVEC's Anchorage

headquarters. Other equipment in the prime power plant includes space heaters, engine cooling systems, fire suppression, DC power supply, and other necessary equipment. Outside, three single-phase transformers are installed on an elevated fiberglass I-beam frame, a 3,000-gallon secondary intermediate supply tank sits in an elevated containment box, and spill containment equipment is stored ready for deployment in two metal shipping containers placed on ground in the fenced yard and secured with buried anchors to prevent their movement during flood events.

The Alakanuk standby generation module is a single enclosure containing one Caterpillar model C27 generator rated at 800kW, plus batteries, controls, fire suppression system, interior daytank and other accessory equipment. It was entirely designed by AVEC's Engineering Department; factory manufactured and outfitted by NC Power Systems pursuant to a competitive bid procurement; and installed onto a driven-steel-pile foundation and connected on site in Alakanuk by field crews from AVEC's Operations Department. Outside, four transformers prepare the generated power for the intertie and local electric grid. Some important field work was outsourced to contractors STG, Inc. (pile foundation and placement of module onto foundation) and Smith Services Alaska LLC (fuel supply line, transformer deck and transformers installation). AVEC signed a long term fuel purchase agreement with Lower Yukon School District (LYSD), which maintains bulk fuel storage proximate to the standby module, whereby LYSD will supply fuel to the standby module during those times when it needs to operate.

HDL designed the AVEC bulk fuel storage facilities. HDL designed the power plant's foundation and structural components, main/generation building and interconnections, with substantial contributions from Gray Stassel Engineering, Inc. (GSE; under contract to HDL) and from AVEC's Engineering Department. AVEC Engineering also designed and/or specified the housing and storage building, as well as the generators and some related components; AVEC procured the generators directly, outside of the construction contract.

The Emmonak AVEC bulk fuel tank farm and the pile foundation for the power plant (phase one) were constructed and completed first, followed by the remainder of the power plant (phase two). The power plant foundation was included in phase one along with the entire BFU so all piling could be driven in a single summer construction season while the major portion of the power plant continued in its design phase, to take best advantage of the large crane and other specialty equipment required to drive the piles, all of which is both expensive to own and operate, and expensive to mobilize into and out of such a remote community. Both phases were constructed following a competitively-bid, fixed-price contracting model according to specifications and contract documents published by HDL. HDL and AVEC conducted two bidding processes and contract awards to match the phases: phase one including all tanks, piling, structural steel and other materials, was put out to bid in December 2013 and the contract was awarded in February 2014; the remainder/bulk of the power plant project but excluding the generators and most distribution work and materials, was put out to bid in November 2014 and the contract was awarded in December 2014. STG, Inc. (STG) was the low bidder for both phases; the two contracts with STG ultimately totaled $11.426 million.

The new AVEC tank farm consists of eleven 50,000-gallon vertical bulk fuel tanks plus one 10,000-gallon horizontal intermediate tank, for a total gross capacity of 560,000 gallons. The horizontal intermediate tank is used to transfer fuel from the bulk storage tanks to the secondary intermediate tank mounted just outside the power plant. Like the power plant, the tank farm sits on a driven-pile foundation (piles are 16" diameter driven to 35 feet); a "bathtub"-style structural steel secondary containment structure divided into four walled cells is attached atop the piles; the twelve total tanks are installed three in each of the four cells, along with associated piping, pumps, electrical and control components, and elevated walkways and stairs. The bulk fuel tanks are filled seasonally through a marine header installed on the south (river) side of the tank farm; fuel barges anchor in the river and run a temporary flex hose to the header during fill operations. To convey fuel to the power plant situated diagonally across the street, a buried supply line featuring integrated containment runs north about 240 feet under Delta Street.

The State of Alaska Oil and Hazardous Substances Pollution control regulations (known as C-Plan) apply to fuel systems with a storage capacity of more than 420,000 gallons per owner or operator. The AVEC tank farm was designed and built to comply with these C-Plan regulations, as well as other code requirements and environmental regulations promulgated by the State of Alaska (in the 2009 edition of the International Fire Code and the International Building Code, adopted by the Dept. of Fire and Life Safety); by the U.S. Environmental Protection Agency (as to the Spill Prevention Control and Countermeasures (SPCC) Plan, and Facility Response Plan (FRP)); and by the U.S. Coast Guard (as to the Facility Response Plan and Operations Manual).

As an additive alternative to the base construction contract and under award 1425, STG also installed an AVEC-supplied 12,000-gallon double-walled tank at the WTP on a timber sleeper foundation and secured with buried anchors to prevent movement during flood events; since it came with integrated double-wall protection, this tank needed no additional secondary containment. STG also refurbished and extended the life of the WTP's four existing tanks comprising about 30,000 gallons storage; the tanks were sandblasted, repainted, reset into code-compliant containment on a new timber-sleeper foundation, and new welded pipes, valves, gauges, etc., were installed. The City uses a small tanker truck to refill these five smaller tanks as needed from City bulk storage tanks at the existing community tank farm. The new heat recovery loop running from the power plant to the WTP is anticipated to significantly reduce the WTP's fuel consumption and thus reduce the required number of tanker truck deliveries.

Procurement and construction ramped up in spring 2014. A three-foot-deep gravel pad was built and compacted; some classified fill material was required but not available locally, and was barged about 70 miles to the site from a borrow source near the upriver community of St. Mary's. By June all bulk storage tanks, steel piles and other structural steel, power plant building components and essentially all other major materials were onsite in Emmonak, and driving of the BFU piles through the gravel pad was well underway. Through the summer the structural steel deck and containment walls were welded atop the piles, and tanks were placed and fully piped and interconnected. Also a temporary fuel supply line to the still-operating old power plant, and full security fencing and security lighting were installed. Substantial completion inspection was conducted in October 2014, attended by representatives of AVEC, HDL, Engineering Design and Consulting (EDC, subcontractor to HDL), and STG; a punch list of remaining required work

was created. The new AVEC tank farm was filled from a tanker barge in fall 2014. After all punch list items were addressed, a second inspection was conducted May 2015 (attended by representatives of HDL and STG only) and AVEC then accepted the project.

For the new power plant, foundation piles were driven and the steel pan deck was welded atop the piles in late fall 2014, then construction was shut down for the winter. In spring 2015, a concrete floor was poured into the steel deck; through the summer, the steel frame for the generation building was erected and the insulated panels and other building envelope components were installed and the housing/storage building was erected. Essentially all exterior work was complete before winter, allowing interior construction to continue through the winter; from early fall 2015 through spring 2016 the gensets and all other interior components were installed and prepared for energizing, and the transformers and 3,000-gallon secondary daytank were installed on the exterior deck. Some of this later work was accomplished by AVEC field crews working in conjunction with STG. Substantial completion inspection was conducted in February 2016 (attended by representatives of AVEC, HDL, GSE, and STG); the project was deemed not substantially complete and a punch list of remaining required work was created. The new power was commissioned in April 2016. A second inspection was conducted May 2016 (attended by representatives of HDL and AVEC only) and AVEC then accepted the project. Early performance data is encouraging: in calendar 2017 (first full year of operation), the new power plant serving both Emmonak and Alakanuk averaged 14.29 kWh per gallon, whereas in calendar year 2015 (last full year of operation), the old Emmonak power plant generated an average of 12.9 kWh per gallon of fuel consumed; this indicates a fuel efficiency improvement of just over 10%.

Some work continued into spring - summer 2016: all old AVEC fuel tanks in Emmonak were cut up and placed into the local landfill operated by the City (scope included assisting the City in obtaining necessary state permits to authorize such disposal). In summer – fall 2016 a transformer deck was added to the Alakanuk standby module, transformers were installed there, and the module's fuel supply line was installed underground to the school's bulk fuel tanks. In winter 2016 – 2017, final distribution improvements were completed to fully connect the standby module to the intertie, and the old Alakanuk power plant was taken offline. In spring 2017 the old AVEC tanks in Alakanuk were rendered permanently unusable.

**Funding and Costs** - Funding to date has been provided by Denali Commission to AVEC, and matching cash contributions from AVEC, as shown in the following table:

| Funding and Outlays, Project 1425: Emmonak RPSU and BFU, and Alakanuk RPSU | Federal portion of award | AVEC match portion | Total All Sources |
|---|---|---|---|
| DC award 1425 | $ 13,217,241 | $ 2,923,213 | $ 16,140,454 |
| Total Funding (Budget) | $ 13,217,241 | $ 2,923,213 | $ 16,140,454 |
| | | | |
| DC award 1425 Outlays | $ 13,217,241 | $ 2,923,213 | $ 16,140,454 |
| Outlays not funded (cost overrun) | | $ 29,008 | $ 29,008 |
| Total Actual Outlays | $ 13,217,241 | $ 2,952,221 | $ 16,169,462 |
| | | | |
| Outlays in excess of funding | | $ 29,008 | $ 29,008 |

Total outlays ($16,169,462) exceed total formal funding ($16,140,454) by $ 29,008. Since no further federal funding or other funding is currently forthcoming, this shortfall is considered an additional AVEC match portion at this time.

**Conclusions** - The completed project meets all current regulations and codes governing electrical generation and fuel storage facilities of this size. The new energy infrastructure features far greater protection from expected flood events than did the aging facilities it replaced, and the power plant itself produces more electric power and more recovered heat than the old plant. The project was built on schedule and within budget.

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